Development of a Novel Gas Pressurized Stripping (GPS)-Based Technology for CO_2 Capture from Post-Combustion Flue Gases

Project Continuation Request for Initiating Budget Period 3 Tasks

DOE funding award DE-FE0007567

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Carbon Capture Scientific, LLC.

May 9, 2014

Pittsburgh, PA

CARBON CAPTURE SCIENTIFIC, LLC.

Purpose and Presentation Outline

Purpose: Present BP2 progress and accomplishments and actual status of achievement against success criteria. Present project continuation request and agree with DOE-NETL to proceed to Budget Period 3 tasks.

Presentation Outline:

- Project background
- Project progress and accomplishment in Budget Period 2
- Key Budget Period 2 milestone status
- Project continuation request and agreement with DOE-NETL to proceed to Budget Period 3 tasks
- Tasks, milestone and success criteria for Budget Period 3
- Budget status and budget projections for Budget Period 3

About Carbon Capture Scientific, LLC

- Early stage company located in Pittsburgh, PA
- Two patent granted CO_2 capture technologies
- Bench-scale development funded by the Department of Energy / National Energy Technology Laboratory
- Chemical Engineers/Scientists with strong expertise in process design, simulation and optimization
- Technology development based on transition from thermodynamic analysis, to process simulation, to bench scale prototyping

Project Participants

Partner/ Organization	Lead Contact(s)	Key Role(s)
DOE-NETL	Andrew P. Jones, Project Manager	-Funding & Sponsorship
Carbon Capture Scientific, LLC	Shiaoguo (Scott) Chen, PI Zijiang (John) Pan, Co-PI	-Process optimization -Bench-scale experiments
CONSOL Energy Inc.	Daniel P. Connell, Co-PI Richard Winchel, Technical advisor	-Phase equilibrium experiments and related process design
Nexant Inc.	Gerald Choi, PI Robert Chu, Sr. Chemical Engineer	-Techno-economic analysis
Western Kentucky University	Prof. Wei-Ping Pan, PI	-Consultant on corrosion testing
HiGee USA	Prof. Jiangfeng (Jeffery) Chen PI	-Specialty equipment (RPB) provider

Project Budget

Project duration: 10/1/2011 – 6/30/2015

	BP1		BP2		BP3		
	10/01/11-09/30/12		10/01/12-06/30/14		07/01/14-06/30/15		
	Government Share	Cost Share	Government Share	Cost Share	Government Share	Cost Share	Total
CCS, LLC	$802,593	$254,342	$1,312,921	$223,182	$223,813	$68,136	$2,884,987
CONSOL	$147,549		$40,000		$40,000		$227,549
Nexant	$89,027		$67,385		$88,865		$245,277
WKU	$14,989	$0	$44,059	$14,009	$0	$0	$73,057
HiGee USA			$109,999	$180,177	$18,550	$11,334	$320,060
Total	$1,054,158	$254,342	$1,574,364	$417,368	$371,228	$79,470	$3,750,930

Project Objectives

Overall Objective

- Develop a breakthrough Gas Pressurized Stripping (GPS) process-based technology for CO_2 capture from post-combustion flue gases.

Specific Objectives

- Perform bench-scale tests of individual process units to obtain necessary process design data for the pilot scale.
- Conduct computer simulations to maximize the benefit of the GPS technology for existing power plants.
- Carry out experimental investigation of selected solvents to minimize the economic risk of the GPS technology.
- Perform bench-scale tests of a rotating packed bed (RPB) to evaluate cost reduction potential.
- Design, build, and test a GPS skid capable of processing 500 SLPM actual coal-derived flue gas in a column-based GPS system operating at the National Carbon Capture Center (NCCC).

BP2 Tasks

Task #	Description	Simulation / Experiment	Focus
1	Project planning & management		**Project management**
3	Optimization of GPS process for existing plant	Simulation	Identify optimal operating conditions for GPS process
4	Simulation of alternative separation for GPS stripping gas	Simulation	Identify separation process to follow GPS process
7	GPS column design/ fabrication and testing	Experiment	Experimentally validate GPS concept
8	Second absorption column testing	Experiment	To recover stripping gas
10	Corrosion test at high loading and high temperature	Experiment	Obtain corrosion data
11*	RPB unit evaluation at CCS Laboratories	Experiment	Assess RPB potential to replace conventional column
14	Revision of techno-economic analysis	Simulation	Identify cost reduction potential
16*	GPS system design/ fabrication and installation	Experiment	Establish a skid mounted GPS system

**** Revised or new task for BP2***

Revised Milestones for BP2

Task	Title/Description	Planned Completion Date	Actual Completion Date	Verification Method
1	Host site agreement executed	6/30/2013	7/2/2013	Written notification from NCCC
3	Overall energy performance of system less than or equal to 0.22 kwh/kg CO_2	9/30/2013	12/31/2012	Review with NETL / Presentation of data
4	Overall energy performance of system less than or equal to 0.20 kwh/kgCO_2	9/30/2014	2/25/2013	Review with NETL / Presentation of data
7	GPS column efficiency experimental measured at 50% or greater	9/30/2013	2/25/2013	Review with NETL / Presentation of data
14	Capital cost of the GPS process is no more than 20% higher than conventional amine-based processes	9/30/2013	2/25/2013	Review with NETL / Presentation of data
16	Complete design of bench-scale GPS test unit for conventional columns	4/30/2013	5/20/2013*	Design report
16	Completion of the fabrication and shakedown of the skid-mounted GPS system using water and air	6/30/2013	Projected 5/16/2014	Review with NETL / presentation of data
16	Complete installation of 500 SLPM column-based GPS bench unit at NCCC	8/31/2013	Projected 6/30/2014	Review with NETL / NCCC

*Process design was modified multiple times after submission with helps from NCCC

Quantitative Success Criteria for BP2

Task	Description	Planned Completion Date	Actual Completion Date	Verification Method
3	Overall energy performance of column and solvent less than or equal to 0.22 kwh/kg CO_2	9/30/2013	12/30/2012	Review with NETL / Presentation of data
4	Overall energy performance of system less than or equal to 0.20 kwh/kgCO_2	9/30/2014*	2/25/2013	Review with NETL / Presentation of data
7	GPS column efficiency experimental measured at 50% or greater	9/30/2013	2/25/2013	Review with NETL / Presentation of data
14	Capital cost of the GPS process is no more than 20% higher than conventional amine-based processes	9/30/2013	2/25/2013	Review with NETL / Presentation of data

* Originally success criteria for BP3

Project Progress and Accomplishments by Tasks (BP2)

Task	Description	Key Objectives	Accomplishments
1	Project plan and management	Management	Updated SOPO and PMP
3	GPS optimization for existing plant	Achieve overall energy performance ≤0.22 kwh/kg CO_2	**Success criteria met**
4*	GPS simulation for alternative separation processes	Achieve energy performance of ≤ 0.20 kwh/kg CO_2	**Success criteria met**
7	GPS column design/ fabrication & testing	GPS column efficiency ≥ 50%	**Success criteria met**
8	2nd absorber design/ fabrication & testing	CO_2 content in stripping gas <5%	Achieved
10	Corrosion testing at high loading & temperature	Testing corrosion rate for carbon steel and stainless steel under various condition	Corrosion manageable
11*	RPB unit evaluation at CCS Laboratories	Obtain design modification for RPB under GPS operation	RPB reduce equipment footprint by 20X or more
14	Revision of techno-economic analysis	GPS capital increase ≤ 20% of DOE baseline	**Success criteria met**
16*	GPS skid design/ fabrication and installation	Fabricate GPS skid for 500 SLPM flue gas and be tested at NCCC	Design/fabrication completed Shakedown test in progress

* Revised or new tasks for BP2

Task 1: Project Planning and Management

Purpose

- Project planning and Management

Accomplishments

- Updated project management plan
- Revised SOPO three times for BP2
  - Introduced Rotated Packed Bed (RPB) into the GPS system to reduce the capital cost of the conventional column based system and design a skid system with dual testing capability with column and RPB
  - Eliminated the dual testing capability of the skid system due to limited budget
  - Revised the Tasks related to testing of the GPS skid at NCCC
- NEPA preparation and review
- Host site agreement

Task 3: Optimization of GPS process for existing plant

Purpose

- To identify optimal design and operating mode of the GPS process for existing power plant

Accomplishment

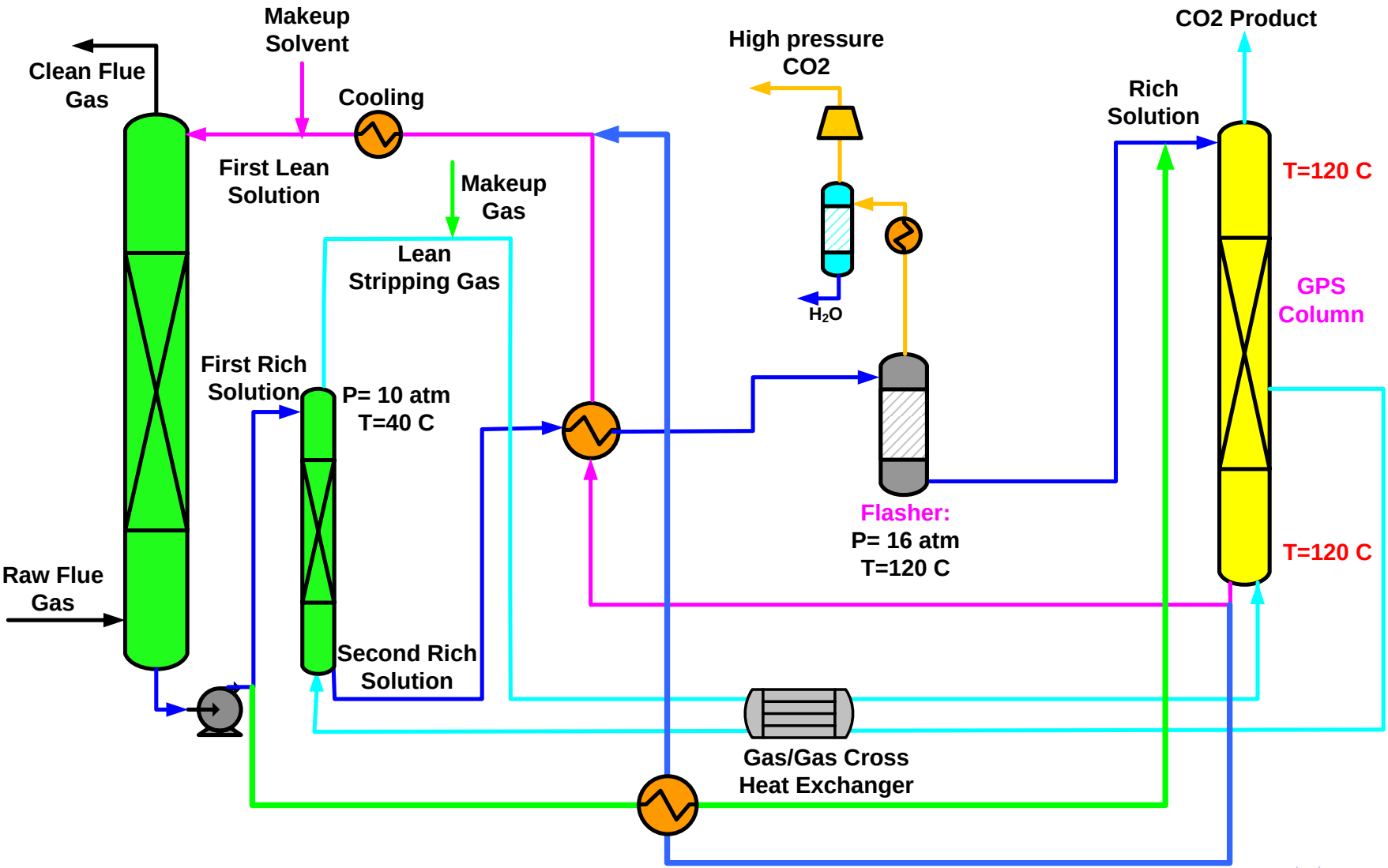
- Guided by techno-economic analysis from Nexant process design and operating conditions of the GPS system were optimized

Items	Baseline MEA	GPS Process
Operating Pressure (atm)	1.8	~10
Reaction Heat (kJ/kgCO_2)	1870	1680
Sensible Heat (kJ/kgCO_2)	990	220
Stripping Heat (kJ/kgCO_2)	690	182
Total Heat (kJ/kgCO_2)	3550	2082
Electricity Equivalent (kWh/kgCO_2)	0.29*	0.13
Other load (kWh/kgCO_2)	0.04	0.04
Compression Work (kWh/kgCO_2)	0.09	0.05
Electricity Equivalent (kWh/kgCO_2)	0.42	0.22**

*No back pressure turbine was used

** Success criteria <0.22kWh/kgCO_2

Task 3: Optimization of GPS process for existing plant



Task 4: Simulation of alternative separation for GPS stripping gas

Purpose

- To identify alternative separation process for stripping gas recovery

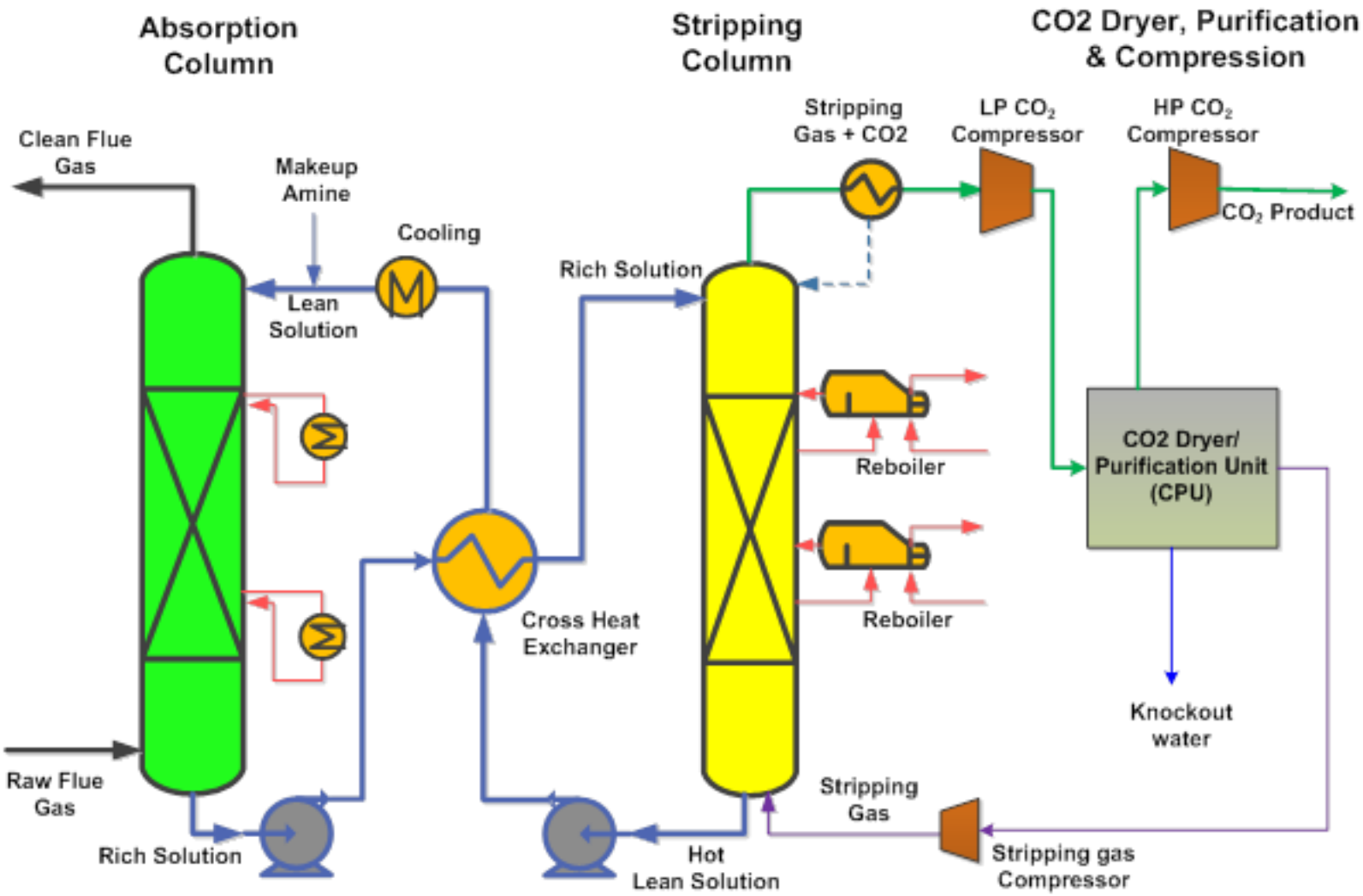
Accomplishment

- Identified compression/refrigeration method as a better alternative to second absorption process, overall energy performance:

Capture percentage, %		**90.20**
CO_2 product purity mol.%	**CO_2**	**97.63**
	H_2O	**0.24**
	N_2	**2.13**
Heat requirement (electricity equivalent), kWh/kg CO_2		**0.131**
Electricity need, kWh/kg CO_2		**0.065**
Overall energy performance, kWh/kg CO_2		**0.196**

Met success criteria of energy performance column and solvent ≤ 0.20 kwh/kgCO_2

Task 4: Simulation of alternative separation for GPS stripping gas



Task 7: GPS column design/ fabrication and testing

Purpose

- To experimentally validate the GPS concept

Accomplishment

- Validated computer simulation results
- Proved GPS can achieve high pressure CO_2 product
- Energy efficiency is much higher
- Produced pure enough CO_2 product without second absorption or compression/refrigeration

Task 7: GPS column design/ fabrication and testing

Run	1	2	3	4	5	6
liquid flow rate (g/min)	74.4	65.5	115	115	110	110
Heat GPS (W)	93.9	83	154.9	192.7	137	146
Sensible Heat (W)	29.0	25.5	64.1	96.1	48.9	73.5
Reaction + Stripping (W)	64.9	57.5	90.8	96.6	88.0	72.5
Equivalent Reaction + Stripping (KJ/Kg CO2)	1377	1386	1248	1327	1266	1042
Theoretical Minimum	818					

$$\Delta H_{min} = R \frac{T_2 T_1}{T_2 - T_1} \ln\left({}^{P_2}/_{P_1}\right)$$

$$\frac{\Delta H_{min}}{\Delta H_{exp}} = \frac{818\ {}^{\text{kJ}}/_{\text{kg}}\,\text{CO}_2}{1274\ {}^{\text{kJ}}/_{\text{kg}}\,\text{CO}_2} = 64\%$$

Experimentally observed GPS operations achieving a thermal efficiency of 64% (milestone of 50%)

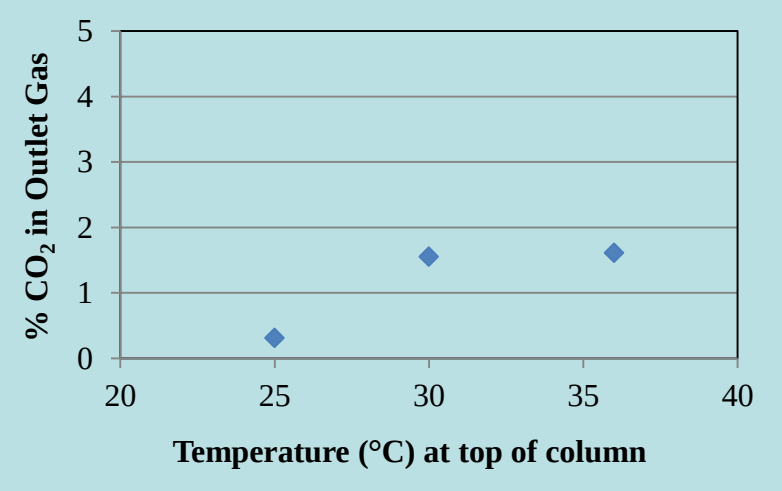
Task 8: Second Absorption Column Test

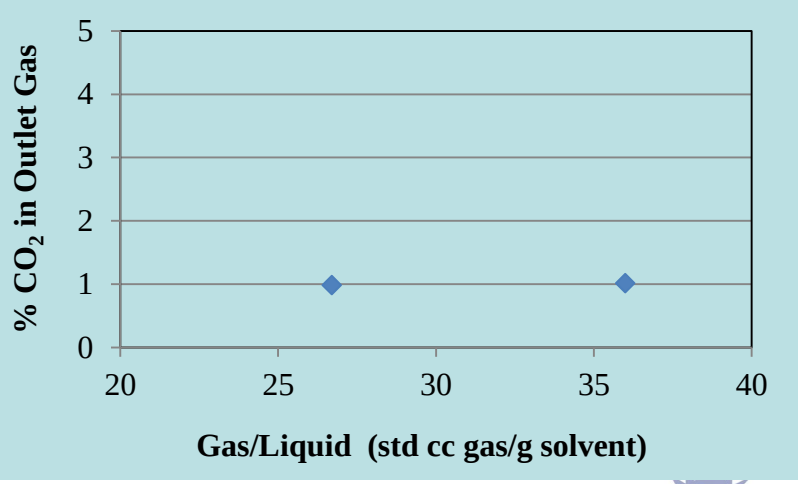
Purpose

- Recover the stripping gas in purity of 95% (CO_2 < 5%vol.)

Accomplishment

- Designed, fabricated and tested the 2nd absorption column.
- Performed parametric tests including temperature and gas/liquid ratio.
- Obtained the anticipated experimental results: stripping gas can be easily recovered by the 2nd absorption for CO_2 concentration < 5%vol.



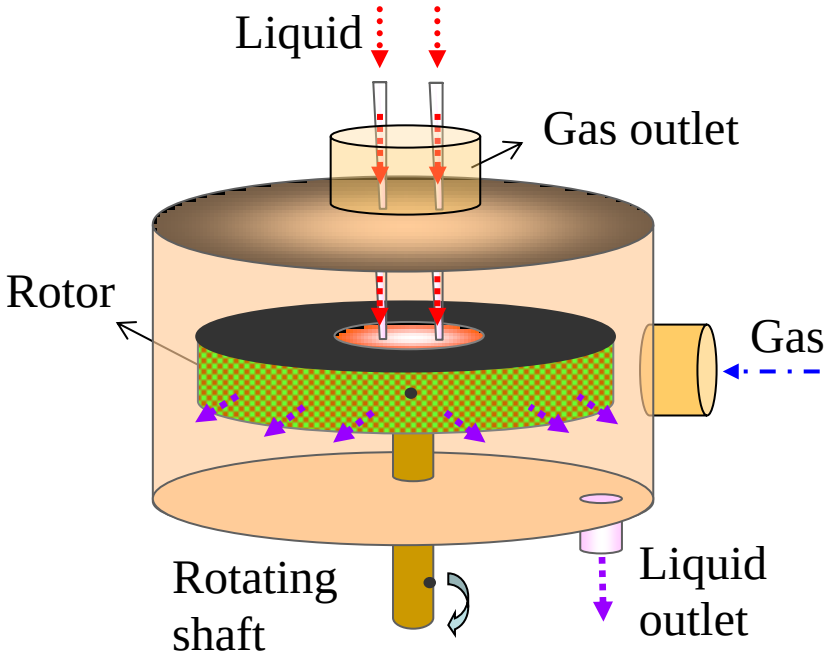


Task 10: Corrosion Test at High Loading and Temperatures

$$k = \frac{weight\ lost}{surface\ area * density * exposure\ time}$$

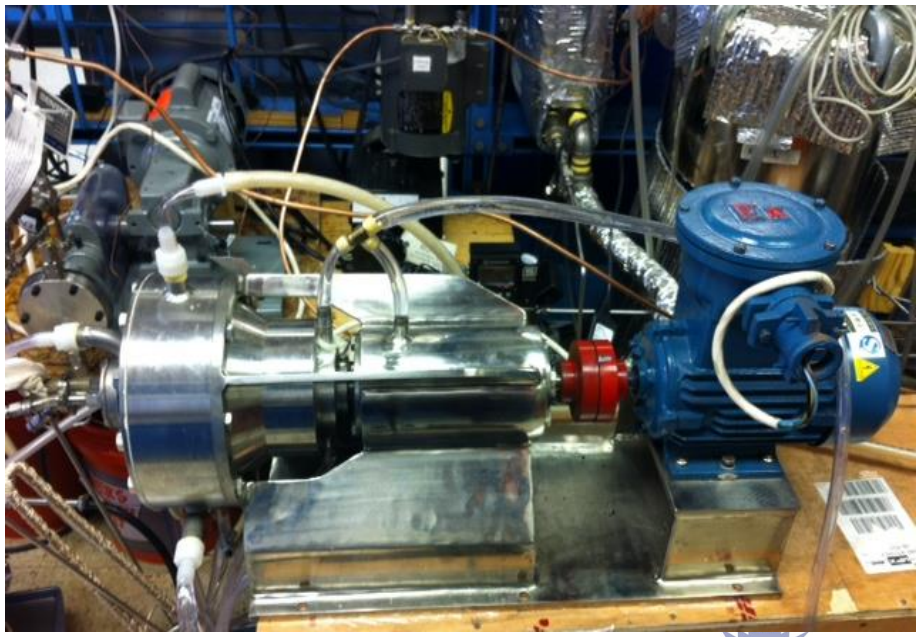
CCS Solvent										
	Rich solvent			Lean solvent					Lean Solvent with O_2	
	20 C	50 C	80 C	20 C	50 C	80 C	100 C	110 C	20 C	50 C
Stainless 304L	0.032	0.044	0.08	0.031	0.097	0.058	0.306	0.961	0.011	0.048
Stainless 316 L	0.109	0.025	0.254	0.013	0.046	0.072	0.279	0.84	0.053	0.057
Carbon Steel	0.024	0.035	0.114	0.033	0.035	0.27	0.363	1.23	0.035	0.197

Task 11. RPB Unit Evaluation at CCS Laboratories



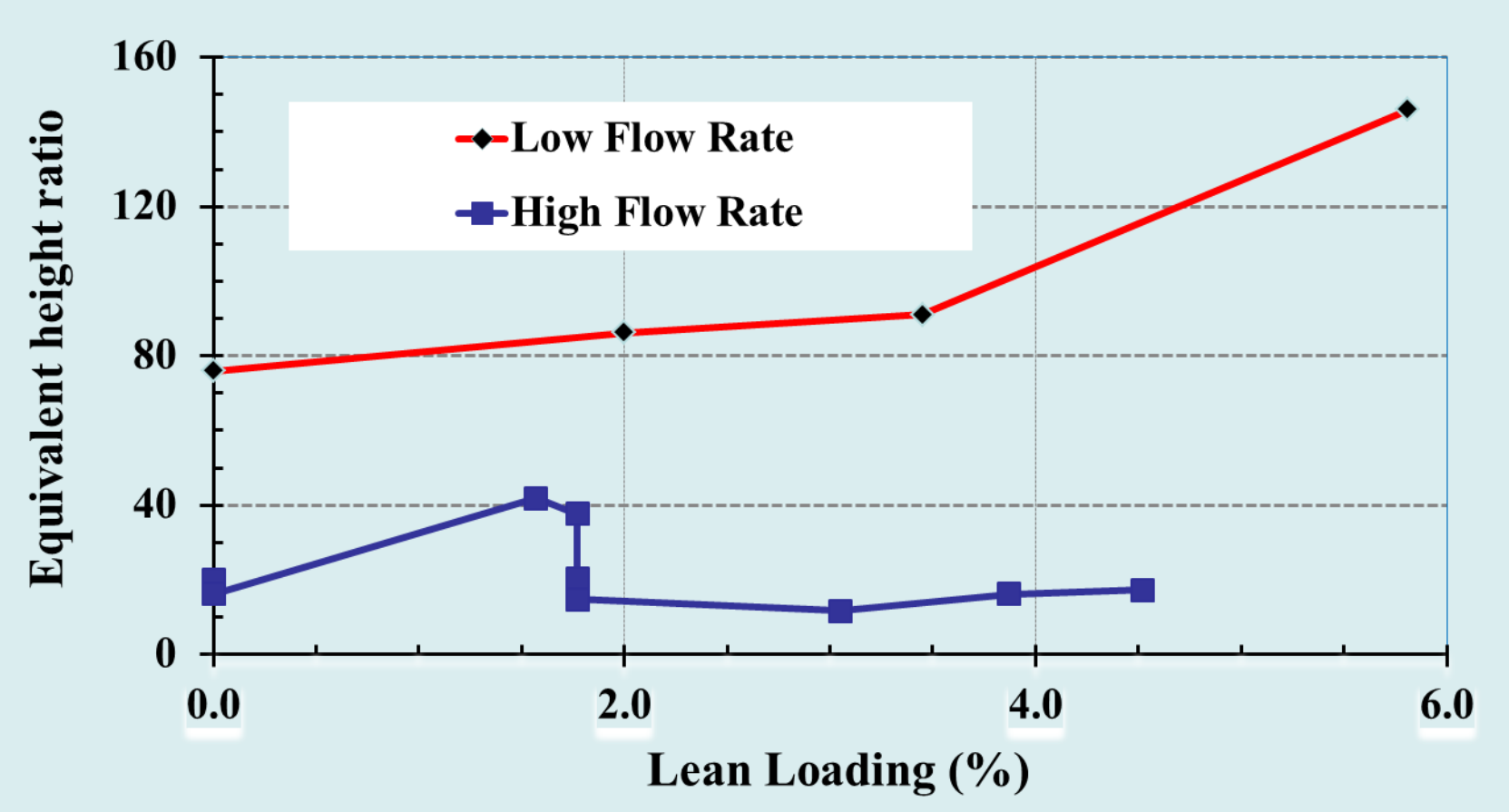
Schematic of Rotating Packed Bed

Lab Scale Rotating Packed Bed

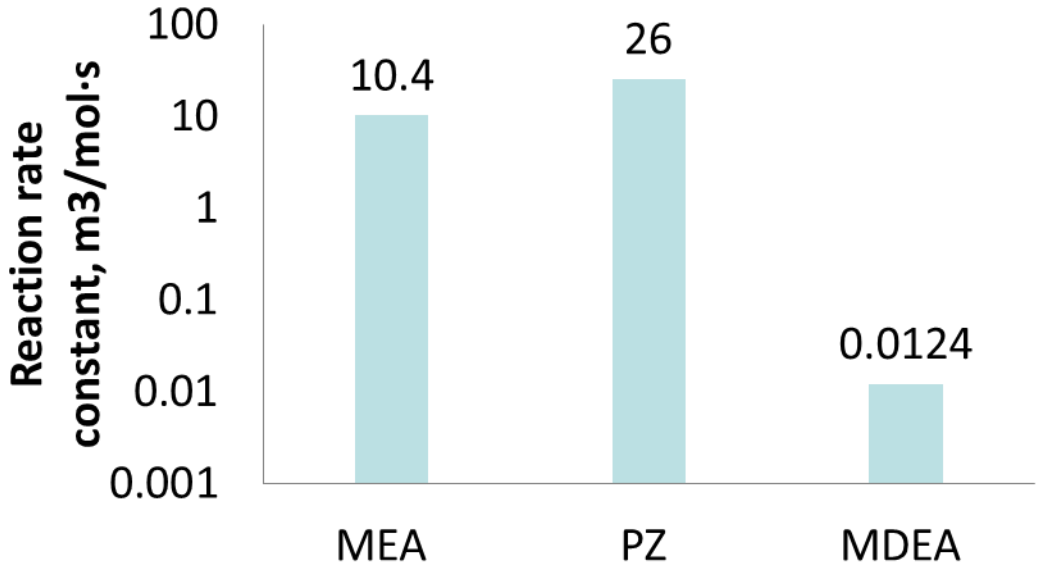


Task 11. RPB Unit Evaluation at CCS Laboratories

Equivalent Height Ratio =
Equivalent Column packing height/RPB packing height



Task 11. Intrinsic Reaction Rate and RPB Residence Time



Gas Phase Residence Time in Lab RPB: 1.3s

Amine	Rate Constant k_2	[Amine]	Reaction Rate	Time to absorb one mol CO_2/L	RPB typical residence time
	m^3/mol·s	mol/m^3	mol/m^3·s	s	s
MEA	10.4	3000	97107.56	0.010	
PZ	26	3000	242768.9	0.004	0.1
MDEA	0.0124	3000	115.7821	8.637	

Task 14. Revision of Techno-Economic Analysis

Purpose

- To reassess techno-economic performance for GPS technology based on new information

Accomplishment

- Guided computer simulation task to optimize process
- Achieved capital equipment cost increase of <20% milestone

	Baseline Case 12	GPS 20% Recycle	GPS/Refrigeration
Total Output at Generator Terminals, kW	663,445	753,660	761,644
Auxiliary Load Summary, kW:			
Coal Handling and Conveying	490	490	490
Limestone Handling & Reagent Preparation	1,270	1,270	1,270
Pulverizers	3,990	3,990	3,990
Ash Handling	760	760	760
Primary Air Fans	1,870	1,870	1,870
Forced Draft Fans	2,380	2,380	2,380
Induced Draft Fans	10,120	10,120	10,120
SCR	70	70	70
Baghouse	100	100	100
FGD Pumps and Agitators	4,250	4,250	4,250
Misc Balance of Plant	2,000	2,000	2,000
Steam Turbine Auxiliaries	400	400	400
Condensate Pumps	630	630	630
Cooling Water Circulation Pumps **	12,260	*15,476*	15,476
Cooling Tower Fans	6,340	*4,459*	4,459
Transformer Losses	2,300	*2,613*	2,613
Amine CO_2 Capture Plant Auxiliaries	21,320	*22,243*	22,568
CO_2 Compression	46,900	*33,828*	34,100*
Total Auxiliaries, kW	117,450	*106,949*	107,546
Net Power Export, kW	545,995	*646,711*	654,098
Net Plant Efficiency, % HHV	27.2	*32.2*	32.6
Net Plant Heat Rate, Btu/kW	12,536	*10,584*	10,464

*was calculated based on 5C of DOE oxyfuel report

Task 14: Revision of Techno-Economic Analysis

Type of CO_2 Capture Technology	Case 11 (No Capture)	Case 12 (MEA Baseline)	GPS with 20% Recycle	GPS Refrigeration
Power Production, MW				
Gross Power	580	663	754	762
Net Power	550	546	647	654
Capital Cost, $MM				
Power Plant	866.4	1109.9	1123.7	1123.7
PCC Plant	0.0	**410.8**	**470.9**	**447.5**
CO2 Compression and Drying	0.0	**46.4**	**55.0**	**75.8**
Start Up Costs (2% TPC)	15.5	26.4	27.6	27.7
Total Capital Cost, $MM	881.9	1,593.5	1,677.3	1674.7
Operating Cost excl Fuel, $MM/yr				
Fixed Operating Cost	13.8	20.5	22.9	22.9
Variable Operating Cost				
Non PCC related Opt Cost	20.0	33.6	35.6	35.6
NaOH		0.9	0.9	0.9
H2SO4		0.3	0.3	0.3
Amine M/U		1.0	1.1	1.1
Active Carbon		0.6	0.5	0.5
Corrosion Inhibitor/Solvent MU		0.0	0.0	0.0
Total Operating Cost excl Fuel, $MM/yr	33.8	56.9	61.3	61.3
Fuel Cost, $MM/yr	64.5	92.0	92.0	92.0
LCOE (excl CO2 TS&M), mills/kWh	**63.9**	**112.0**	**98.7**	**97.6**
% of Case 11 LCOE - Compare to 2007	**100%**	**175%**	**154%**	**153%**

Task 16: GPS Skid Design/ Fabrication and Installation

Purpose

- To build a 10kWe (500SLPM) skid mounted continuous GPS system to be tested in real flue gas at NCCC

Accomplishments

- Completed process design (P&ID) with assistance from NCCC
- Changed vendor for skid fabrication to ensure quality
- All safety designs approved by NCCC (DHR meeting)
- Finished skid fabrication
- Shakedown tested GPS skid system
- Prepared Tier I and Tier II documents as required by NCCC

Task 16: GPS Skid Design/ Fabrication and Installation

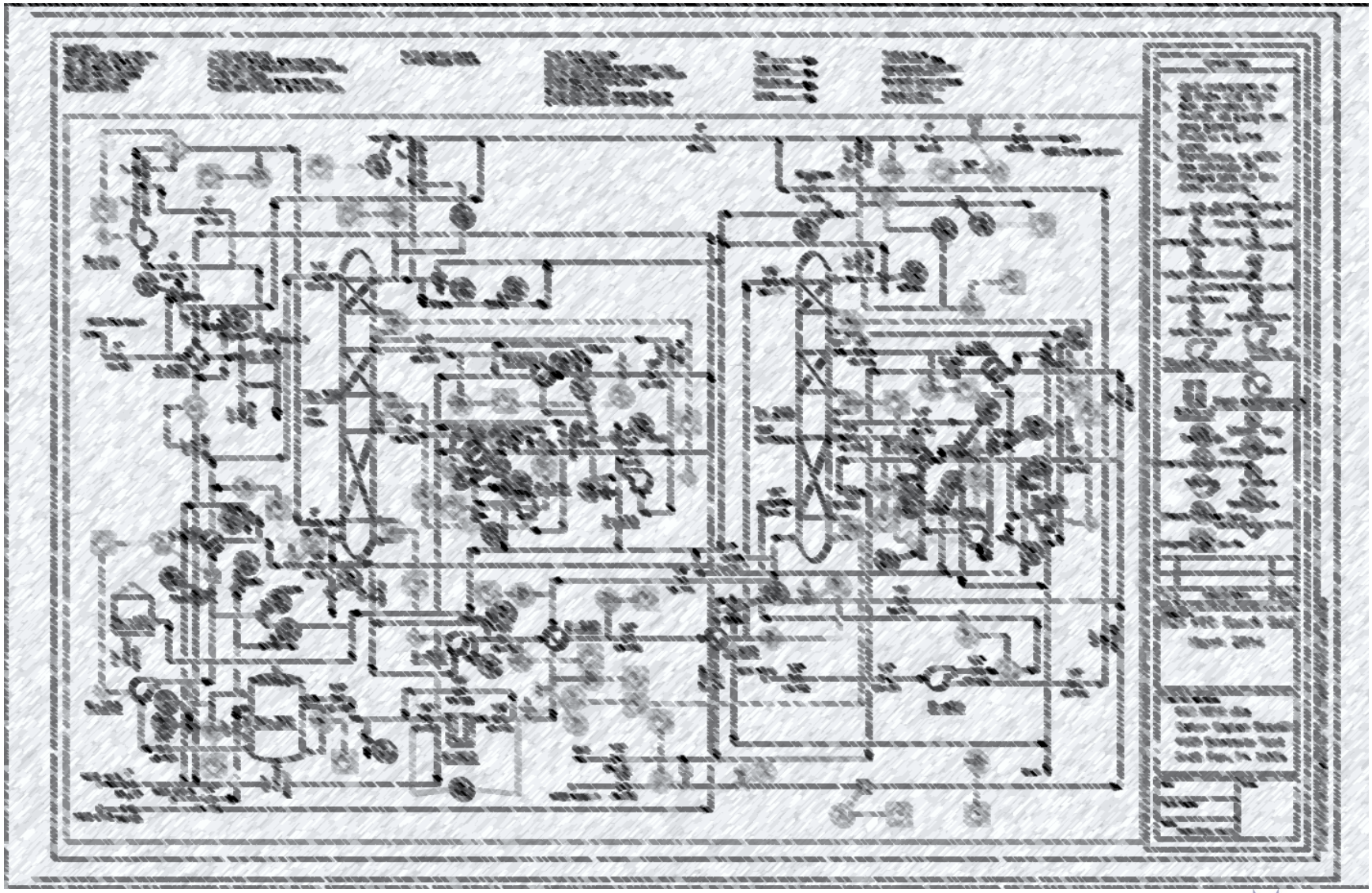
NCCC interactions

- CCS team visited NCCC in January 2013 and April 2013
- CCS skid design review meeting on 11/20/2013
- CCS skid DHR meeting on 2/20/2014
  - Addressed a few changes of skid design and fabrication
  - Management of Changes were made and reviewed by NCCC team
- Several CCS-NCCC conference call

Vendor change

- Stopped Daylight Engineering activities
- Screened 7 potential vendors
- Signed contract with Ascension Industries

Task 16: GPS Skid Design/ Fabrication and Installation



Task 16: GPS Skid Design/ Fabrication and Installation

Fabrication of the skid system has been finished

Task 16: GPS Skid Design/ Fabrication and Installation

- **Shakedown tests in progress and will be finished by May 16, 2014**
- **Skid shipment is planned on May 19, 2014**

Task 16: GPS Skid Design/ Fabrication and Installation

Tier I documents

- Process Flow Diagram
- Preliminary P&ID's
- Major Equipment Specifications
- Design Pressures and Temperatures for each line/component noted on P&ID's
- Completed Work Plan that has been agreed to by the NCCC and the test partner
- Desired pressures and capacities for all process flows (process gases, utilities, vents, waste streams, and electricity)
- Estimated Motor Loads
- Test Partner Project Milestone Schedule
- General dimensions of process skid(s)
- Requested analyses from NCCC as well as summary of analytical equipment provided by test partner

Tier II documents

- Final P&ID's
- Equipment/Instrument Specifications
- Design Pressures and Temperatures for each piece of equipment, vessel, and all process piping
- Finalized Material Specifications
- Final Pressure Vessel fabrication drawings, U-1 reports, and code calculations
- Finalized process capacities and line sizes
- Finalized design, fabrication, and assembly schedule
- Test plan including commissioning and startup sequence, test matrix, operating parameters, etc.
- Finalized design drawings of process skid(s) and equipment showing dimensional details, anchor bolt patterns, location of all tie-in points, and weight of skid(s)
- All electrical loads, single line diagram, and motor elementaries
- System Communication needs* (connection to HMI's, DSL needs, wireless needs, etc.)

Funding and Costing Profile by Quarter for BP2

Baseline Reporting Quarter	BP2: Status 10/01/12 Ends 06/30/14						
	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Baseline Cost Plan							
Federal Share	224435	224435	224435	224435	224436	224436	224436
Non-Federal Share	63104	63104	63104	63104	63105	63105	63105
Total Planned	287539	287539	287539	287539	287541	287541	287541
Cumulative Baseline Cost	1596039	1883578	2171117	2458656	2746197	3033738	3321279
Actual Incurred Cost							
Federal Share	187571	203877	301255	265154	66439	269025	307135
Non-Federal Share	18458	90669	126497	25023.1	53897	73379	60031
Total Incurred Cost	206029	294546	427752	290177	120336	342405	367166
Cumulative Incurred Cost	1539349	1833895	2261647	2551824	2672160	3014565	3381731
Variance (Actual - Plan)							
Federal Share	-36864	-20558	76820	40719	-157997	44589	82699
Non-Federal Share	-44646	27565	63393	-38081	-9208	10274	-3074
Total Variance	-81510	7007	140213	2638	-167205	54864	79625
Cumulative Variance	-56690	-49683	90530	93168	-74037	-19173	60452

Budget Status for BP2

Total Cost	BP2 Original			BP2 (Thru 04/27/2014)			BP2 (Projected)			BP2 Projected		
	DOE	Cost Share	Total	DOE	Cost Share	Total	DOE	Cost Share	Total	DOE	Cost Share	Total
Personnel	$349,540	$123,451	$472,991	$398,173	$168,814	$566,987	$44,926	$23,265	$68,191	$443,099	$192,079	$635,177
Fringe Benefits	$90,181	$31,850	$122,032	$102,729	$43,554	$146,283	$11,591	$6,002	$17,593	$114,319	$49,556	$163,876
Travel	$34,707	$0	$34,707	$10,014	$0	$10,014	$9,889	$0	$9,889	$19,903	$0	$19,903
Equipment	$390,000	$0	$390,000	$378,949	$0	$378,949	$10,750	$0	$10,750	$389,699	$0	$389,699
Supplies	$19,500	$0	$19,500	$13,961	$0	$13,961	$0	$0	$0	$13,961	$0	$13,961
Other	$30,000	$0	$30,000	$37,995	$0	$37,995	$10,000	$0	$10,000	$47,995	$0	$47,995
Contractual	$0	$0	$0									
Consol Energy	$40,000	$0	$40,000	$11,063	$0	$11,063	$740	$0	$740	$11,803	$0	$11,803
Nexant Inc.	$67,385	$0	$67,385	$54,932	$0	$54,932	$0	$0	$0	$54,932	$0	$54,932
HiGee USA	$100,000	$190,177	$290,177	$21,775	$80,460	$102,234	$0	$0	$0	$21,775	$80,460	$102,234
WKU	$30,000	$0	$30,000	$10,000	$14,007	$24,007	$0	$0	$0	$10,000	$14,007	$24,007
Subcontractor Total	$237,385	$190,177	$427,562	$97,770	$94,467	$192,236	$740	$0	$740	$98,510	$94,467	$192,976
Total Direct Charges	$1,151,313	$345,478	$1,496,792	$1,039,591	$306,834	$1,346,425	$87,896	$29,267	$117,163	$1,127,487	$336,101	$1,463,588
Overhead 46.29%	$423,057	$71,889	$494,946	$435,969	$98,305	$534,274	$40,345	$13,548	$53,892	$476,314	$111,853	$588,166
Total Cost	$1,574,371	$417,367	$1,991,738	$1,475,560	$405,139	$1,880,699	$128,240	$42,815	$171,056	$1,603,800	$447,954	$2,051,754

Project Continuation Request to Proceed to Budget Period 3 Tasks

- Project team has completed or positioned to complete by end of BP2 all milestones and met all success criteria.
- The superior performance of the GPS technology is clearly demonstrated by experiments and techno-economic analysis.
- Host site agreement completed.
- GPS skid of 500 SLPM will be installed.

Project team, therefore, requests:

- Continue project and proceed with Budget Period 3 tasks.
- Budget Period 3 from July 1, 2014 to June 31, 2015.
- Update project management plan and SOPO as appropriate.
- Negotiating budget modifications.
- Update PMP.

Planned Tasks for BP3

Task	Title/Description	Focus	Organization	Duration
1	Project Planning & Management	Project management	CCS	7/1/14~6/30/15
12	Survey of EH&S of GPS process	EH&S survey	CCS	1/1/15~6/30/15
15.0	Updated techno-economic analysis		NEXANT	7/1/14~6/30/15
15.1	Equipment sizing using updated data	Economics	NEXANT	7/1/14~12/31/14
15.2	Techno-economic analysis	Economics	NEXANT	1/1/15~6/30/15
17.0	Bench-Scale Testing of the Skid Mounted Column Based GPS System	Experimental	CCS	7/1/14~6/30/15
17.1	Bench unit commissioning	Process	CCS	7/1/14~7/31/14
17.2	Bench unit parametric testing	Process	CCS	8/1/14~9/30/14
17.3	Bench Unit long-term testing	Process and solvent	CCS	10/1/14~4/30/15
17.4	Equipment tear down and return to CCS facilities	Process	CCS	5/1/15~6/30/15

Subtask 17.1 Bench Unit Commissioning

Purpose

- Shakedown testing and calibrating the column based GPS system to ensure that the system works properly

What to accomplish

- **Solvent preparing and loading**
- **Shake down test**
  - **Test of utility systems**
  - **Test of safety systems per NCCC requirement**
  - **Test of operation and automation functions**
  - **Functional test of critical sub-systems, including flue gas cooling system, absorber, GPS stripper, and heat exchangers**
  - **Calibrations of all measurements and analytical devices if needed**
- **Start up and steady state test**
- **Sampling test**
- **Heat loss calibration**

Subtask 17.2 Bench Unit Parametric Testing

Purpose

- To conduct steady state parametric tests of the GPS system at NCCC

What to accomplish

- Investigate the effect of following parameters on CO_2 separation performance:
  - Total gas flow rate
  - Gas/Liquid mass ratio
  - GPS column operating pressure
  - Stripping gas flow rate

Subtask 17.3 Bench Unit Long-Term Testing

Purpose

- The objective of this long-term testing campaign is to validate solvent stability and other parameters affecting long-term performance

• What to accomplish

- To run the skid GPS system under continuous, steady-state and optimal conditions identified from parametric tests for at least 2000 hour.
- Solvent degradation will be assessed
- Identify any long term issues with the GPS system

Subtask 17.4 Bench Unit Decommissioning

Purpose

- To bring the GPS system from NCCC back to CCS for future use

What to accomplish

- Tear down the GPS system
- Ship the skid system back to CCS

Proposed Milestones for BP3

Task	Title/Description	Planned Completion Date	Verification Method
1	Project Planning and Management	6/30/2015	Final Technical Report
12	Completion of Preliminary EH&S Assessment	6/30/2015	Topical Report
15	Completion of techno-economic analysis of the GPS system using updated data	6/30/2015	Topical Report
17	Complete commissioning of the skid-mounted GPS system at NCCC	7/31/2014	Review with NETL / NCCC
17	Completion of the parametric tests of GPS system at NCCC	9/30/2014	Review with NETL /NCCC
17	Completion of the cumulative running time of the GPS skid for more than 2000 hours	3/31/2015	Review with NETL / NCCC
17	Completion of equipment tear down and return to CCS facilities	6/30/2015	Review with NETL /NCCC

Quantitative Success Criteria for BP3

Task	Description	Planned Completion Date	Actual Completion Date	Verification Method
15	Increase in capital equipment costs of less than or equal to 10% over existing process	6/30/2015		Topical Report and Review with NETL
17	Overall energy requirement of the GPS process less than electricity equivalent of 0.23kWh/kgCO_2	9/30/2014		Review with NETL / NCCC
17	Cumulative running time of the GPS system for >2000 hours	3/31/2015		Review with NETL / NCCC

Budget for BP3 Original and Revised

Total Cost	BP3 Original			BP3 Revised			Project Total		
	DOE	Cost Share	Total	DOE	Cost Share	Total	DOE	Cost Share	Total
Personnel	$81,473	$37,024	**$118,497**	$218,757	$54,688	**$273,445**	$970,490	$384,922	$1,355,412
Fringe Benefits	$21,020	$9,552	**$30,572**	$56,439	$14,110	**$70,549**	$250,386	$99,310	$349,696
Travel	$38,999		$38,999	$31,627	$0	$31,627	$58,212	$0	$58,212
Equipment			$0		$0	$0	$389,699	$0	$389,699
Supplies	$8,500		$8,500	$13,500	$0	$13,500	$173,399	$0	$173,399
Other	$3,000		$3,000	$13,000	$0	$13,000	$64,001	$0	$64,001
Contractual			$0						
Consol Energy	$40,000		$40,000	$5,000	$0	$5,000	$164,352	$0	$164,352
Nexant Inc.	$88,865		$88,865	$88,865	$0	$88,865	$232,824	$0	$232,824
HiGee USA	$18,550	$11,334	$29,884	$0	$0	$0	$21,775	$80,460	$102,234
WKU			$0	$0	$0	$0	$24,989	$30,091	$55,080
Subcontractor Total	$147,415	$11,334	$158,749	$93,865	$0	$93,865	$443,940	$110,551	$554,491
Total Direct Charges	$300,407	$57,910	$358,317	$427,188	$68,798	$495,986	$2,350,128	$594,783	$2,944,911
Overhead 46.29%	$70,820	$21,560	$92,380	$154,295	$31,846	$186,142	$889,313	$231,596	$1,120,909
Total Cost	$371,227	$79,470	$450,697	$581,484	$100,644	$682,128	$3,239,441	$826,379	$4,065,820

BP3 Schedule Update

Task #	Project Milestone Description	BP3 Duration 7/1/2014 ~6/30/2015				Planned Start Date	Planned End Date	Comments
		Q1	Q2	Q3	Q4			
1.0	**Project planning /management / reporting**					**10/1/2011**	**9/30/2014**	
12.0	**Survey of EH&S of GPS process**					**4/1/2014**	**9/30/2014**	
15.0	**Updated techno-economic analysis**					**7/1/2014**	**3/31/2015**	**Focus on techno-economics**
15.1	Equipment sizing using updated data					7/1/2014	12/31/2014	
15.2	Techno-economic analysis					10/1/2014	3/31/2015	
17.0	**Bench-Scale Testing of the Skid Mounted Column Based GPS System**					**7/1/2014**	**6/30/2015**	**Focuses on skid unit testing at NCCC**
17.1	Bench unit commissioning					7/1/2014	7/31/2014	
17.2	Bench unit parametric testing					7/1/2014	9/30/2014	
17.3	Bench Unit long-term testing					10/1/2014	3/31/2015	
17.4	Equipment tear down and return to CCS facilities					4/1/2015	6/30/2015	Tear down of the system

Questions/ Comments?